

Design Review System in Virtual Reality (VR)

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Abstract

The products we develop and manufacture are reviewed at each production stage. In the design review, which is conducted at the final design stage, 2D drawings are used, making it difficult to grasp the image after assembly.

We have introduced 3D design to some of our products and applied Virtual Reality (VR) technology to design reviews, which has improved process efficiency and quality. In VR reviews, we take advantage of the virtual space to consider adding objects, changing shapes, and comparing multiple models. Compared to conventional design reviews, the shape recognition at the design stage has become easier and the quality of comments and improvement suggestions has improved.

1 Preface

Computer System Manufacturing Unit at our System Equipment Factory Complex is responsible for the development, production, and maintenance of computer-applied system products. This includes the Supervisory Control And Data Acquisition (SCADA), remote supervisory control and data acquisition (Telecon), and Overhead Catenary System (OCS) inspection system called “CATENARY EYE”, as well as protective relay equipment. The development and production of various devices involves a design process, and design deliverables are reviewed to ensure quality. With the conventional method using drawings, there may be differences in the final form envisioned by each review participant. This paper introduces the mechanism and effects of Virtual Reality (VR) design reviews, which we are currently working on to solve this issue.

2 VR Design Review

2.1 Design Review

For products with development and new design elements, design reviews are conducted to confirm the validity of the design deliverables against the required specifications, extract problems, and determine whether it is OK to proceed to the next step in the process. Design reviews are conducted in the form of meetings involving relevant depart-

ments and experts using design deliverables, including 2D drawings.

2.2 Previous Issues

In previous design reviews using 2D drawings, there was an issue that experience was required to imagine a three-dimensional image from a monochrome plan view. It is particularly difficult for review participants outside the design department to imagine the finished product from a 2D drawing.

Our company incorporates 3D design, mainly with CATENARY EYE, but it is difficult to grasp the actual product size image even when looking at a 3D object on the display screen. For example, it is difficult to confirm whether there is a gap where a worker’s hand or tool can easily fit in when assembling the product.

Fig. 1 shows a typical product development process. In the event that a defect could not be identified in the design review, it could be discovered in the assembly process or actual machine review. The later in the process a defect is discovered, the more work that will be required to correct the defect and the greater the delay in the entire process.

2.3 Introduction of VR

In fiscal year 2018, we introduced VR equipment for the purpose of product introduction tour programs. By applying this VR technology to the

development process, we expect to be able to solve the problems mentioned above. Specifically, it will be possible to check maintenance spaces and working postures during assembly in the pre-process, which were not possible by checking 2D drawings alone.

2.4 System Configuration

Fig. 2 shows the system configuration of the equipment and software used.

(1) VR Ready Personal Computer (PC)

VR requires real-time spatial rendering. Since this processing requires high-speed computing

power, this system uses Dell’s ALIENWARE, which was used as a VR PC, and NVIDIA’s GeForce RTX 2080Ti as the Graphics Processing Unit (GPU). Table 1 shows the specifications of the PC. Note that a separate business PC is used for 3D design work.

(2) Head Mounted Display (HMD)

A display device that the VR experimenter wears on the head to cover the eyes. The HMD and the sensors and controllers described below were made using the VIVE Pro from HTC Corporation, which has a proven track record in our VR factory inspection tour programs. In front of both eyes is a display that projects the VR space as seen by each eye, and the VR space can be made to look three-dimensional by utilizing the parallax between the left and right. It is connected to the PC via a headset cable.

(3) Controller

A rechargeable handheld device. It can detect the actions of grasping, pulling the trigger, and mov-

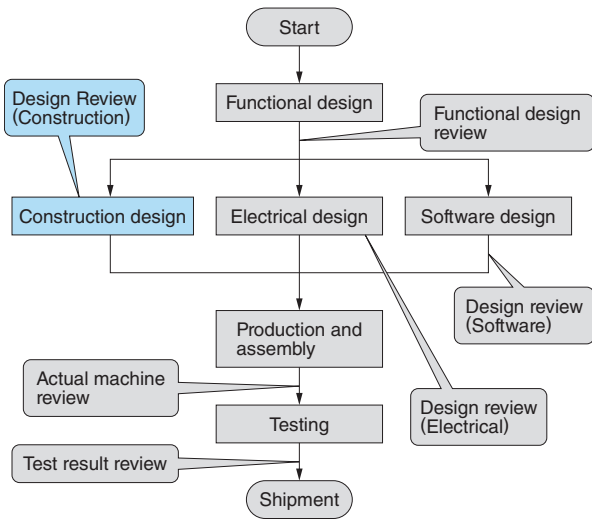


Fig. 1 Typical Product Development Process

A product development process in the computer process unit is shown. The target is the construction design review.

Table 1 Specifications of PC

Specifications of the PC used for the VR design review are shown.

Items	Specifications
Product name	ALIENWARE AREA-51 R5
OS	Windows10
CPU	Intel Core i9-9980XE
GPU	GeForce RTX 2080Ti
Memory	32.0 GB
Storage	C-drive: 1.8 TB HDD

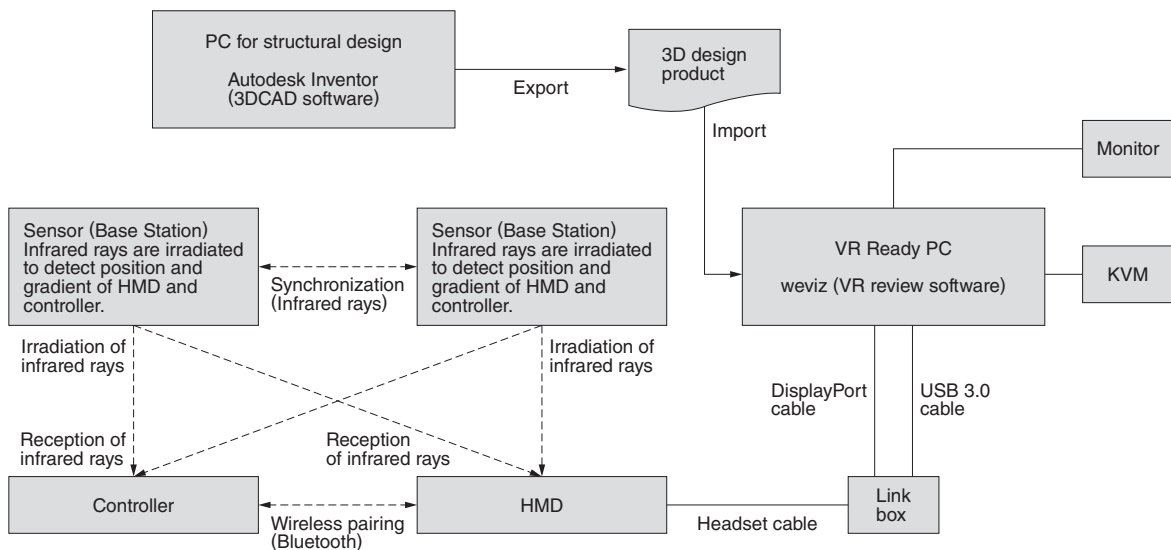


Fig. 2 System Configuration

The system configuration is shown for the VR design review at the computer system unit.

ing/pushing the slide pad. By linking these actions with actions in the VR space, it becomes possible to perform various operations on 3D objects.

(4) Sensor (base station)

Two sensors are used to emit infrared rays to detect the position and orientation of the HMD and controller. It is installed so that the movement space falls within the infrared irradiation range.

(5) Software

For 3D design, we use Autodesk Inventor, a CAD software for the manufacturing industry.

VR reviews can be performed by outputting the design deliverables from the CAD software as STEP files and importing them into weviz, a software designed for reviews. In the virtual space using weviz, you can not only view the imported model in actual size, but also hold it in your hands and check it from various angles.

3 Effect of VR Review

A VR review was conducted for CATENARY EYE in Fiscal Year 2022. As a preliminary step, the design deliverables were imported into weviz, but this work takes about 5 minutes for a typical CATENARY EYE: STEP file for vehicle roof-mounted equipment in Category Class 4, so the burden on the designer is very small. In the VR review, an environment similar to that of an actual machine review was created in a virtual space, and actual workers checked life-size objects from various angles and evaluated the design deliverables by operating the attachment and detachment of covers. In addition, by taking advantage of the ease of changing the placement of objects, which is a feature of VR review, the effects of VR review were maximized by selecting the optimal model using multiple placement models, adding objects and changing their shapes within the review and reflecting them in the design deliverables. The VR review shortened the development process and improved the completeness of the design deliverables.

Table 2 shows a comparison between conventional review and VR review. It shows the number of reworks after the design completion review for properties of the same size as the properties for which VR reviews were conducted. From this result, it can be said that by pointing out problems early in the process, it is possible to prevent reworks in the later process, and the quality of the design has improved.

Table 2 Comparison between Conventional Review and VR Review

The result of comparison is shown between the number of VR review execution objects and other objects of the same scale regarding the number of reworks after execution of reviewing.

Item	Conventional review			VR review object
	Object A	Object B	Object C	
Design date (year)	2019	2020	2020	2022
Number of reworks after design completion (cases)	6	4	1	0

4 Future Outlook

4.1 Resolving Device Issues

The HMD adopted in Section 2.4 requires a wired connection to the PC and the installation of an infrared sensor. Therefore, the PC must be moved to the conference room and the infrared sensor must be installed every time a review is held, which takes time for preparation and cleanup. In order to reduce this installation time, we are considering adopting a standalone HMD that does not require a connection to a PC during operation.

4.2 Operation Improvements

Currently, due to the software specifications and the number of devices, multiple people cannot wear the HMD at the same time, so one person is in the virtual space and the other participants view the virtual space projected on a large screen. In the future, by applying the metaverse technology to VR reviews, which would allow multiple people to enter the same virtual space at the same time, we can expect to conduct design reviews that are closer to actual device reviews and support participants from remote locations.

4.3 VR Use Cases

Using VR makes it easier to imagine the finished product at an early stage. By having customers experience this 3D design deliverable in VR, we can expect to reduce mismatches in perception between our customers and our company.

5 Postscript

The application of xR^{※1} technology, including VR, to the manufacturing industry is currently widespread. 3D design and VR design reviews using the results of that design are a more effective method of

front-loading, so active use is anticipated.

Going forward, we will continue to work on in solving the issues listed in **Section 4**, while continuing to improve our software and hardware. We will also focus on fostering our talents so we can effectively handle new technologies.

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(Note)

※1. xReality (xR): Collective term of technologies such as Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and Substitutional Reality (SR).